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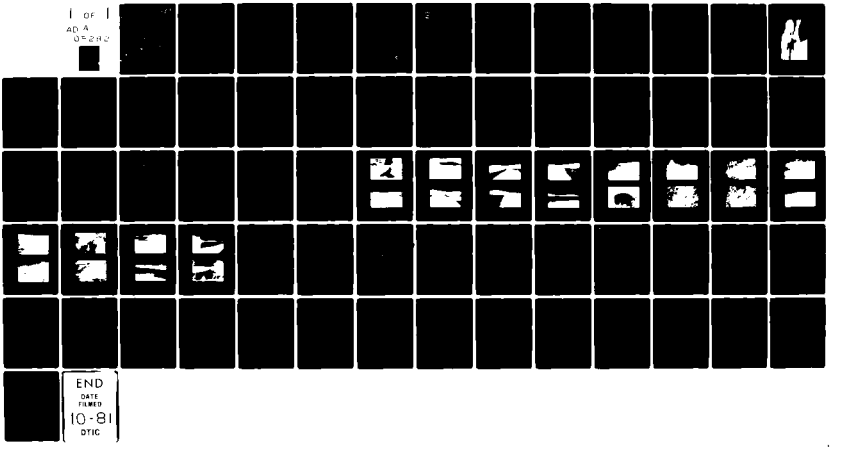

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LAKE NORTHWOODS DAM

GASCONADE COUNTY, MISSOURI

MO. 30110

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

JUNE, 1979

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
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4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Lake Northwoods Dam (MO 30110) Gasconade County, Missouri	5. TYPE OF REPORT & PERIOD COVERED Final Report / 6. PERFORMING ORG. REPORT NUMBER
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National Dam Safety Program. Lake Northwoods Dam (MO 30110), Osage — Gasconade Basin, Gasconade County, Missouri. Phase I Inspection Report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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LAKE NORTHWOODS DAM

GASCONADE COUNTY, MISSOURI

MISSOURI INVENTORY NO. 30110

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY
HOSKINS-WESTERN-SONDEREGGER, INC.
CONSULTING ENGINEERS
LINCOLN, NEBRASKA

UNDER DIRECTION OF

ST. LOUIS DISTRICT, CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

JUNE, 1979

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Lake Northwoods Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Lake Northwoods Dam. It was prepared under the National Program of Inspection of Non-Federal Dams.

SUBMITTED BY: SIGNED — Chief, Engineering Division — 10 DEC 1979 — Date

APPROVED BY: SIGNED — Colonel, CE, District Engineer — 10 DEC 1979 — Date

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
ASSESSMENT SUMMARY

Name of Dam	Lake Northwoods Dam
State Located	Missouri
County Located	Gasconade County
Stream	Tributary Second Creek
Date of Inspection	June 26, 1979

Lake Northwoods Dam was inspected by an interdisciplinary team of engineers from Hoskins-Western-Sonderegger, Inc. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as an intermediate size dam with a high downstream hazard potential. Failure would threaten life and property. The estimated damage zone extends approximately four and one-half miles downstream of the dam. Within the damage zone are two dwellings, State Highway 19 and U.S. Highway 50.

Our inspection and evaluation indicates that the spillway does not meet the criteria set forth in the recommended guidelines for an intermediate dam having a high hazard potential. The Probable Maximum Flood is the appropriate spillway design flood. The spillway will pass the 100-year flood (flood having a one percent chance of being exceeded in any year) without overtopping the dam. The spillway will pass 52% of the Probable Maximum Flood without overtopping the dam. The Probable Maximum Flood (PMF) is defined as the flood that may be expected from the most severe combination of critical meterologic and hydrologic conditions that are reasonably possible in the region.

No design data were available for this dam. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These analyses should be obtained in the future.

Other deficiencies observed during the inspection are small trees and shrubs growing on the downstream slope, seepage outcrops in both

abutment troughs, sloughing of side slopes of the spillway, and seepage from the 6" sewer pipe outletting onto the downstream slope of the dam.

The maintenance of this dam is, in general, good. Preventive maintenance items addressed to tree removal and removal of sloughed side slope materials in the spillway are recommended in the report.

Rey S. Decker
E-3703

Gordon Jamison

Harold Ulmer
Garold Ulmer
E-4777

H. P. Hoskins
Harold P. Hoskins
Chairman of Board
Hoskins-Western-Sonderegger, Inc.
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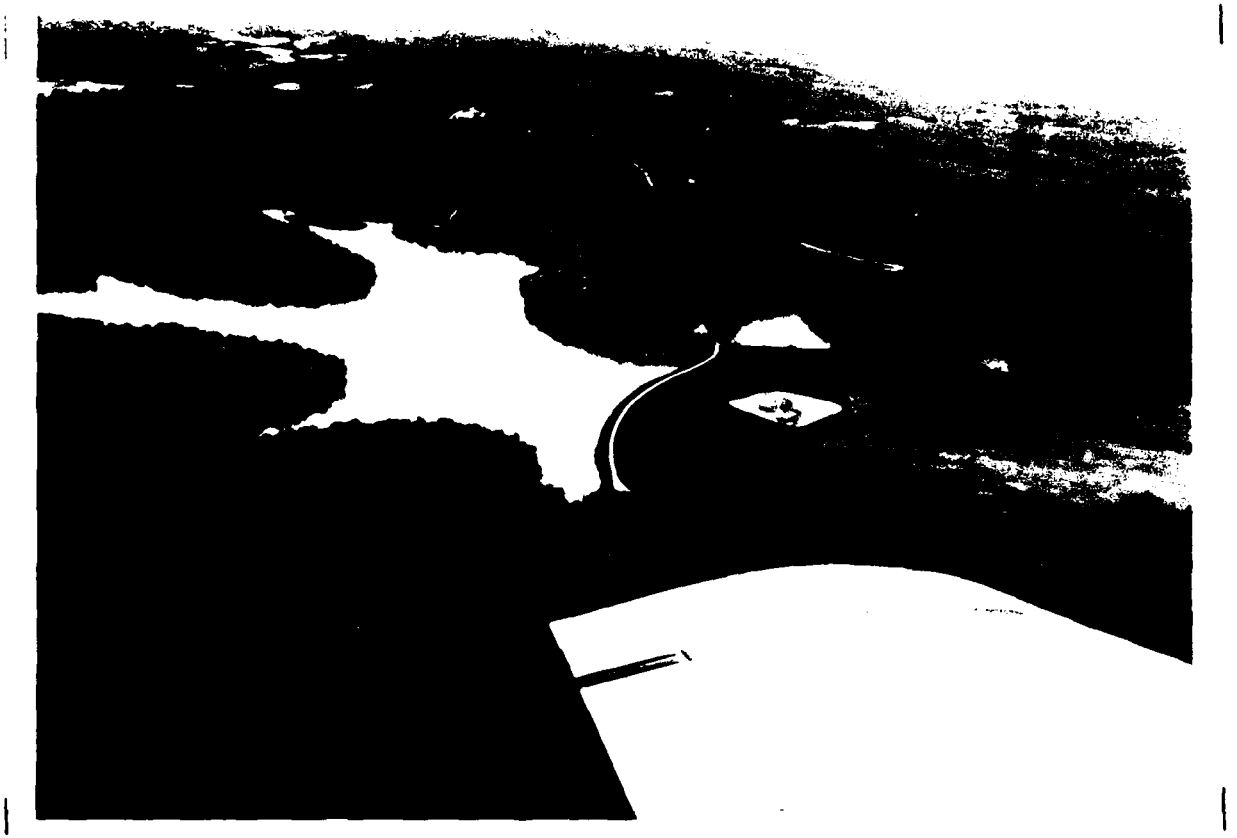


PHOTO NO. 1 - OVERVIEW

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
LAKE NORTHWOODS DAM - MO 30110
GASCONADE COUNTY, MISSOURI

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of Lake Northwoods Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams," Appendix D to "Report of the Chief of Engineers on the National Program of Inspection of Dams," dated May, 1975, and published by the Department of the Army, Office of the Chief of Engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The dam is an earth fill about 1240 feet in length and about 49.5 feet in height located in moderately steep to rolling topography. Upland soils consist of thin loess cover over limestone. Soils on the abutment slopes are probably colluvial or residual cherty clays derived from limestone and shale.

(2) The spillway consists of a channel about 32 feet in width excavated through bedrock (limestone and shale) on the right abutment.

(3) Pertinent physical data are given in paragraph 1.3 below.

b. Location. The dam is located in the east central portion of Gasconade County, Missouri, as shown on Plate A-2. The dam is shown on Plate A-1 in the NW¼ of Section 34, T43N, R5W and the NE¼ of Section 33, T43N, R5W. The lake formed behind the dam is shown in the W½ of Section 34, T43N, R5W, and the E½ of Section 33, T43N, R5W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, this dam and impoundment is in the intermediate size category.

d. Hazard Classification. Guidelines for determining hazard classification are presented in the same guidelines as referenced in paragraph 1.1c above. Based on referenced guidelines, this dam is in the High Hazard Classification. The estimated damage zone extends approximately four and one-half miles downstream from the dam. Within the damage zone are two dwellings, State Highway 19 and U.S. Highway 50.

e. Ownership. The dam is owned by the Lake Northwoods Estate, Inc. c/o William Jafke, 3931 Holly Hills Blvd., St. Louis, MO 63116.

f. Purpose of Dam. The dam impounds a recreational lake covering about 85 acres.

g. Design and Construction History. The dam was constructed in 1968 or 1969. One sheet of construction plans was available from the contractor who built the dam (Mertens Const. Co. Fulton, MO) and is included in Appendix C as part of this report. According to the plans and the owner, a cut off trench (12 ft. bottom with 1H on 1V side slopes) was excavated to rock and the dam was constructed with clay material excavated from the reservoir area and the flatter abutment slopes. According to the Owner, the borrow material was on the wet side of optimum.

h. Normal Operating Procedure. There are no operating facilities for this dam. The reservoir level is controlled by precipitation, infiltration, evaporation and the capacity of the spillway. Maximum observed flow in the spillway was reported by Mr. William Jafke to be 1.5 feet in depth.

1.3 PERTINENT DATA

a. Drainage Area. 1,029 acres (1.61 square miles).

b. Discharge at Damsite.

(1) All discharges at the damsite are through a trapezoidal shaped spillway cut through bedrock (limestone and shale) on the right abutment.

(2) Estimated maximum flood at damsite is 150 to 200 cfs, based on known estimated depth in spillway channel.

(3) The spillway capacity varies from 0 cfs at elevation 786 feet to 2850 cfs at the minimum top of dam (elevation 792.5 feet).

(4) Total spillway capacity at the minimum top of dam is 2850 cfs ±.

c. Elevations (feet above M.S.L.).

(1) Top of dam - 792.5 (low point)
(2) Spillway crest - 786.0 (nominal)
(3) Streambed at centerline - 743±
(4) Maximum tailwater - unknown

d. Reservoir. Length (feet) of maximum pool 3,000±.

e. Storage (Acre-feet).

(1) Top of dam - 1968±
(2) Spillway crest - 1340±

f. Reservoir Surface (Acres)

(1) Top of dam - 110±
(2) Spillway crest - 85±

g. Dam.

(1) Type - earthfill
(2) Length - 1240 feet±
(3) Height 49.5 feet ± (measured)
(4) Top width - 36 to 48 ft. (measured). Plan width - 34 ft.

(5) Side Slopes.
  (a) Downstream - 2H on 1V (plans) and 2.2H on 1V (measured)
  (b) Upstream - 3H on 1V (Plans) 3.5H on 1V (measured, exposed)
(6) Zoning - unknown (plans do not show any)
(7) Impervious core - unknown (plans do not show any)
(8) Cutoff - 12 ft. bottom width, 1H on 1V side slopes excavated to good rock (shown on construction plan and verified by owner).
(9) Grout curtain - none
(10) Wave protection - limestone riprap from crest to 6 ft. below normal pool level.
(11) Internal drainage system - unknown.

h. Diversion Channel and Regulating Tunnel. None

i. Spillway.

(1) Principal (and only)
  (a) Type - trapezoidal channel excavated through limestone and shale on right abutment.
  (b) Control section - natural bedrock, thin bedded limestone.
  (c) Crest elevation - 786 feet
  (d) Upstream Channel - Rock, clean, 100 feet in length, 1% slope.
  (e) Downstream Channel - Rock, clean, 130 feet in length, 4.5% slope, exitting into head cut.

j. Regulating Outlets. Drawdown facility - 8 inch diameter steel pipe w/threaded joints and 5 inch gate valve at outlet.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

The design data that were available for this dam are shown in Appendix C.

2.2 CONSTRUCTION

No construction data were available. It was reported by the Owner that the dam was built in 1968 or 1969. The contractor (Mertens Const. Co.) reported that the dam was constructed according to the plans.

2.3 OPERATION

No data were available on spillway operation. It was reported by Mr. Jafke that the maximum observed depth of flow in the spillway was 1.5 feet and that the drawdown facility is operated every year.

2.4 EVALUATION

a. Availability. Available data were readily obtainable.

b. Adequacy. The available data, field surveys, and visual observation presented herein are considered adequate to support the conclusion of this report. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity. It was reported by Mr. Jafke that the dam was designed by a registered professional engineer.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the Lake Northwoods Dam was made on June 26, 1979. Engineers from Hoskins-Western-Sonderegger, Inc., Lincoln, Nebraska making the inspection were: R. S. Decker, Geotechnical; Gordon Jamison, Hydrology; Garold Ulmer, Civil Engineer; Mr. William Jafke, the Owner, was present during the inspection.

b. Dam.

(1) Geology and Soils. (Abutment and embankment) The geology and soils of the site are described in the report from the Missouri Geological Survey included in Appendix C of this report. Conditions of the report were generally confirmed by observation. Material in the downstream section of the dam is CL-CH soil with considerable cherty gravel probably associated with the Goss soil series.

(2) Upstream slope is well riprapped with durable limestone rock up to 3 feet in maximum dimension with nominal size probably 8 to 12 inches. The riprap looks good with no significant erosion or deterioration. No slides, slumps or deformations were noted on the upstream slope.

(3) Crest. The crest serves as a roadway about 15 feet wide and is well surfaced with crushed limestone. The area on both sides of the roadway is well vegetated with adapted grasses. No cracks, rodent holes or deformation were noted on the crest.

(4) Downstream Slope. The downstream slope is only fairly well vegetated with grasses. A number of old erosional gullies and rills, up to 1 - 1.5 feet in depth were observed on the slope. Most of those are now pretty well stabilized with vegetation. A few small cottonwood and other trees and shrubs are growing on the slope. A seep area occurs along the toe in the right abutment trough between stations 9+25 and 10+00. No flow was observed and the seepage was clear. An auger hole in this area encountered gravel and rocks at a depth of 2 to 2.5 feet which is probably the upper

strata of weathered abutment rock. Another seep area is evident in the left abutment trough, downstream from about station 1+00, at about elevation 764 feet. No free water was evident in the left abutment seep, but the cattail growth was good. It is assumed that the seepage observed in both abutment troughs is passing through the limestone formation in the abutments. Another small seep area was observed downstream from about station 8+50 about 20 feet or one-half way down slope from the crest. This seep results from a small discharge (<1/10 gal./min.) from a 6 inch diameter cast iron pipe outletting on the slope of the dam. It would appear that this pipe is the end of the sewage line from the east side of the lake which is supposed to pass from the nearest manhole (left side of Photo 24) under the reservoir and dam to the sewage lagoon located downstream from the left abutment. The source of the flow in the pipe is not known. There are no sewage hookups on the east side of the lake at the present time. The discharge from the pipe surged, as in response to wave action, which could indicate that one source of flow in the pipe may be seepage into the manhole located in the lake upstream from the dam. No cracks slides or deformations were noted on the downstream slope. The sewage lagoon (see Photos 3, 4 & 10) downstream from the left abutment does not appear to have any adverse affect on the safety of this structure.

(5) Miscellaneous. The nature of materials and the dimensions of this dam indicate that it could probably withstand overtopping by flood occurrences between the 0.5 PMF and the PMF without serious damage.

There is a small dam and lake on a side drainage just north of the left end of this structure. This dam is about 300 feet long, 25 feet high with crest width of 24 feet and side slopes of approximately 3H on 1V upstream and 2H on 1V downstream. Failure of this dam should not affect the Northwoods structure. It would, however, damage the sewage lagoon which is located just downstream from the small dam.

c. Appurtenant Structures.

(1) The spillway consists of a trapezoidal channel cut through bedrock on the right abutment. The bottom of the spillway is cut into thinly bedded limestone which shows some spalling (nothing significant). The sideslopes consist of alternate beds of sandstone, mudstone and limestone. The control and outlet channels appear to be stable. The exit channel is eroded through cherty CL-CH soils down to bedrock. Headcutting through the spillway should not occur. Plans show the bottom width as 40 feet while field measurements indicate a width of 32 feet. There is some slight sloughing of the right cut bank but it would appear that bank sloughing would not account for the 8 foot± difference between planned and constructed bottom width. No significant slides or deformations were noted in the spillway, and it appears to be stable. Two small cottonwood trees are growing on the outside edge of the spillway bottom. The reservoir level was about 0.5 foot below the crest elevation of the spillway at the time of the inspection.

(2) Drawdown facility consists of an 8-inch diameter steel pipe with valve on the downstream end. It was reported by Mr. Jafke that the drawdown valve is operable and that it is opened quite often to be sure it is operating. A pool of water submerges the outlet of the drawdown pipe (Photo 11). This pool does not appear to be caused by seepage but results from surface runoff and drawdown operations (note the muddy water).

d. Reservoir Area. The reservoir is generally surrounded by grass and timber. No significant erosion, slides or slumps were noted around the shoreline.

e. Downstream Channel. The old channel downstream from the drawdown pipe is overgrown with trees and shrubs which should not be detrimental. The channel downstream from the spillway, on the opposite end of the dam from the drawdown pipe, is also overgrown with trees. However, this overgrowth should not affect the planned operation of the spillway.

3.2 EVALUATION

There does not appear to be any serious potential of failure of this structure. Seepage at the toe of the dam is probably transmitted through foundation bedrock. The main section of the dam is dry. The downstream slope is somewhat steep for adequate safety factors against shear failure. Additional studies would be required to determine stability against shear failure, potential damage from overtopping, and the source and affects of seepage in the abutment troughs. Additional studies would also be required to determine the nature and source of the ponded water at the outlet of the drawdown facility.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

There are no controlled outlet works for this dam. The pool level is controlled by rainfall, infiltration, evaporation, and the capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM.

Maintenance of this structure seems to be good,except that the presence of the 6" pipe outlet on the downstream slope, and the seepage therefrom, should be investigated and controlled.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist at this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

Upon checking with the owner, we are unaware of any warning system in effect for this dam.

4.5 EVALUATION

There does not appear to be any serious potential of failure of this structure.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. One sheet of plans was furnished by Mertens Construction Company, Fulton, Missouri.

b. Experience Data. The drainage area, reservoir surface area, and elevation-storage data were developed from the USGS Rosebud, Missouri 7 1/2 minute topographic quadrangle map. The hydraulic computations for the spillway and dam overtopping discharge ratings were based on data collected in the field at the time of the field inspection, and some data extracted from the plans.

c. Visual Observations.

(1) Some sloughing of bedrock material has occurred on the side slopes of the spillway. If this loose material and a few small trees were cleared from the spillway channel it would be more efficient.

(2) The downstream end of the spillway channel has eroded through the surface material to bedrock but poses no threat to the stability of the spillway.

(3) Riprap on the upstream face of the dam appears to be in stable condition.

d. Overtopping Potential. The spillway is too small to pass the probable maximum flood without overtopping. The spillway will pass 52% of the probable maximum flood and the 100-year storm without overtopping. The results of the routings through the dam are tabulated in regards to the following conditions.

Frequency	Inflow Discharge c.f.s.	Outflow Discharge c.f.s.	Maximum Pool Elevation	Freeboard Top of Dam Min. Elev. 792.5	Time Dam Overtopping Hr.
100 Yr.	2380	265	788.0	+4.5	-
0.5 PMF	6730	2630	792.3	+0.2	-
PMF	13,500	10,700*	794.4	-1.9	3+
0.52	7000	2850	792.5	0	-

*(Spillway discharge = 4,880 cfs; top of dam discharge = 5,820 cfs)

According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, this dam is classified as having a high hazard rating and intermediate size. Therefore, the PMF is the test for the adequacy of the dam and its spillway.

The estimated damage zone is described in Paragraph 1.2d in this report.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observation. This dam appears to be structurally stable. There are no indications of deformations or excessive seepage pressures.

b. Design and Construction Data. The geologic evaluation of this dam site was favorable. The available design data are minimal for a structure of this size. No construction data were available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Operating Records. There are no controlled operating facilities for this dam. It was reported by Mr. Jafke that maximum flow depth in the spillway has been observed as about 1.5 feet.

d. Post Construction Changes. The inspection team is not aware of any post construction changes for this dam.

e. Seismic Stability. This dam is located in Seismic Zone 1. An earthquake of the magnitude predicted in this area is not expected to cause structural failure of this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. This structure does not appear to have any serious deficiencies or potential of failure. The spillway will pass one-half the Probable Maximum Flood (PMF) but will not pass the PMF without overtopping. The effects of such overtopping (1.9 ft. for 3 hrs.±) is not known but it would appear that the overtopping would not cause failure of the dam. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available which is considered a deficiency.

b. Adequacy of Information. The conclusions in this report are based upon minimal design data, performance history, and visual observations. Seepage and stability analyses comparable to the requirements of the guidelines were not available which is considered a deficiency.

c. Urgency. The items recommended in 7.2a(1)(2) should be pursued on a high priority basis.

d. Necessity for Phase II. Phase II investigation is not considered necessary.

e. Seismic Stability. This dam is located in Seismic Zone 1. An earthquake of this magnitude is not expected to be hazardous to this dam.

7.2 REMEDIAL MEASURES

a. Alternatives.

(1) Spillway size and/or the height of the dam should be increased to pass the probable maximum flood without overtopping the dam.

(2) The source and purpose of the open pipe and the source of seepage now discharging, therefrom, onto the downstream slope of the dam should be determined and measures taken to correct this situation.

(3) Seepage discharges in the downstream abutment troughs should be monitored for changes in quantity and color.

(4) The pond of water at the outlet of the drawdown pipe should be drained (by pumping or channelization) and inpsected periodically to determine whether or not there is detrimental seepage in this area.

(5) Seepage and slope stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" should be made.

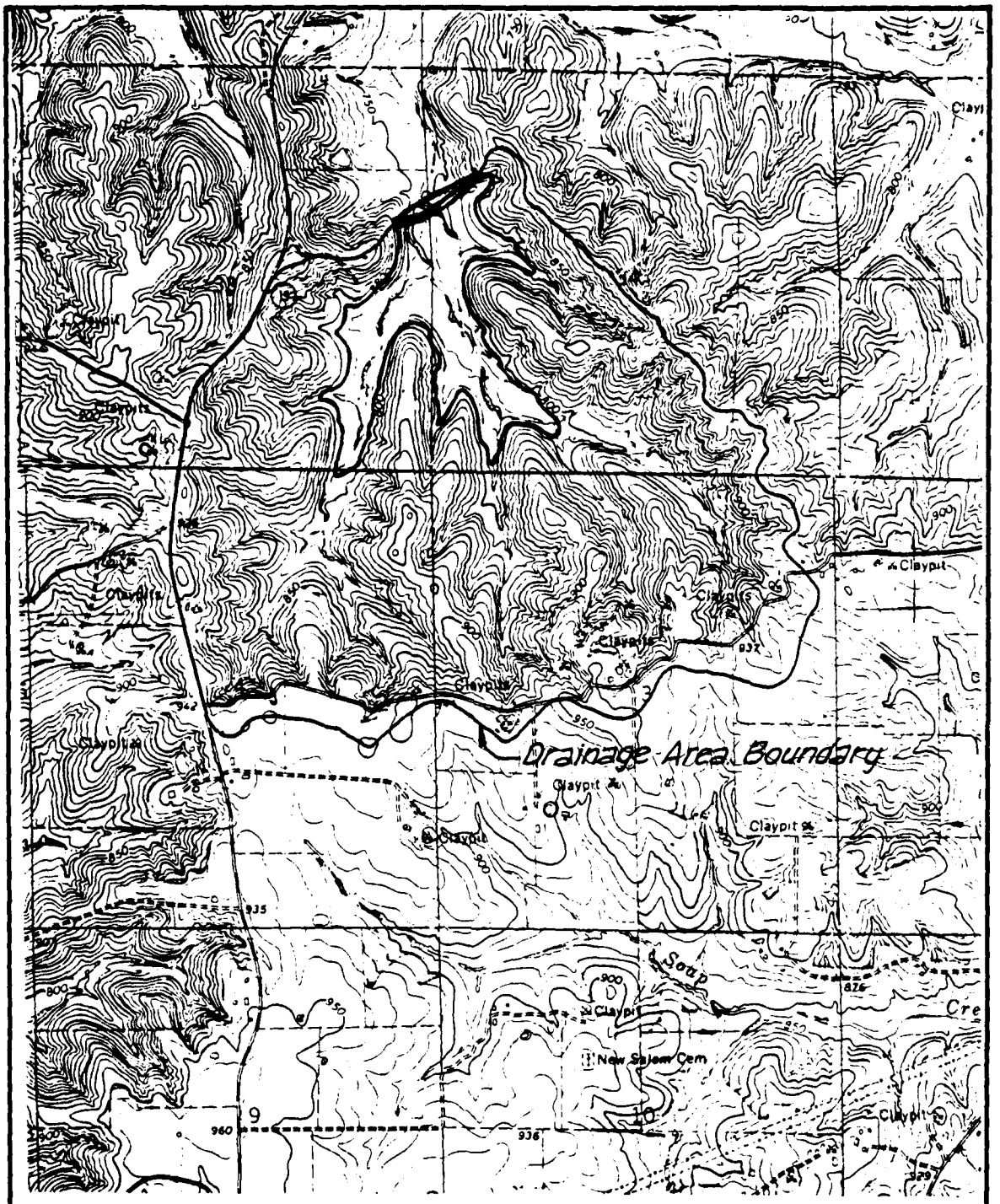
(6) The services of an engineer experienced in the design and construction of earth dams should be obtained to perform the aforementioned studies and analyses and to design protective measures, as required.

b. O & M Procedures.

(1) On the whole, maintenance of this structure is good. The few small trees growing on the downstream slope and in the spillway should be removed and measures taken to prevent their recurrence.

(2) Periodic inspection and removal of the sloughed bank material in the spillway would improve the efficiency of spillway operation.

APPENDIX A
MAPS



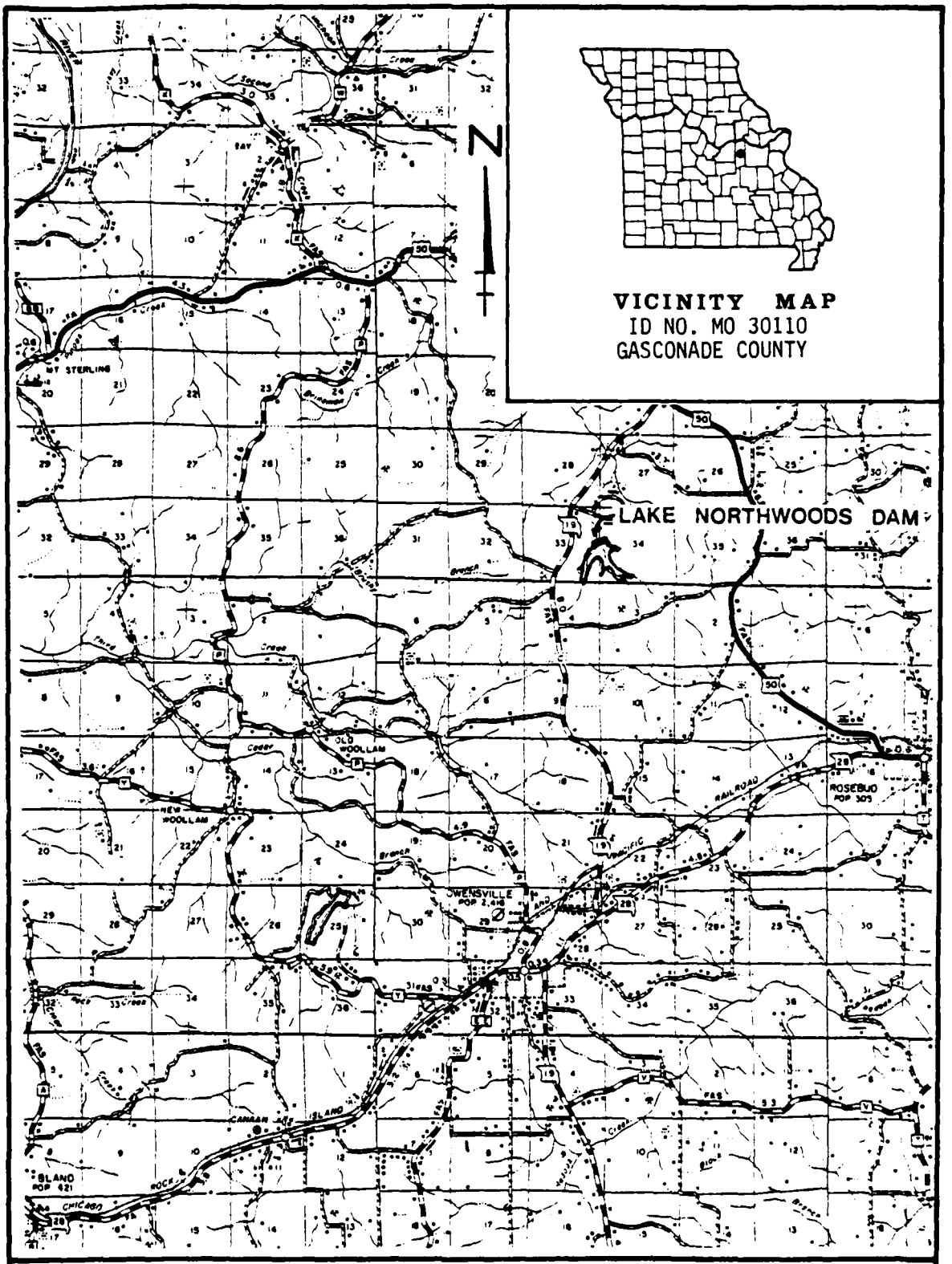
VICINITY TOPOGRAPHY

LAKE NORTHWOODS DAM

GASCONADE COUNTY, MO.

MO. 30110

PLATE A-1



VICINITY MAP
ID NO. MO 30110
GASCONADE COUNTY

LOCATION MAP

PLATE A-2

APPENDIX B
PHOTOGRAPHS

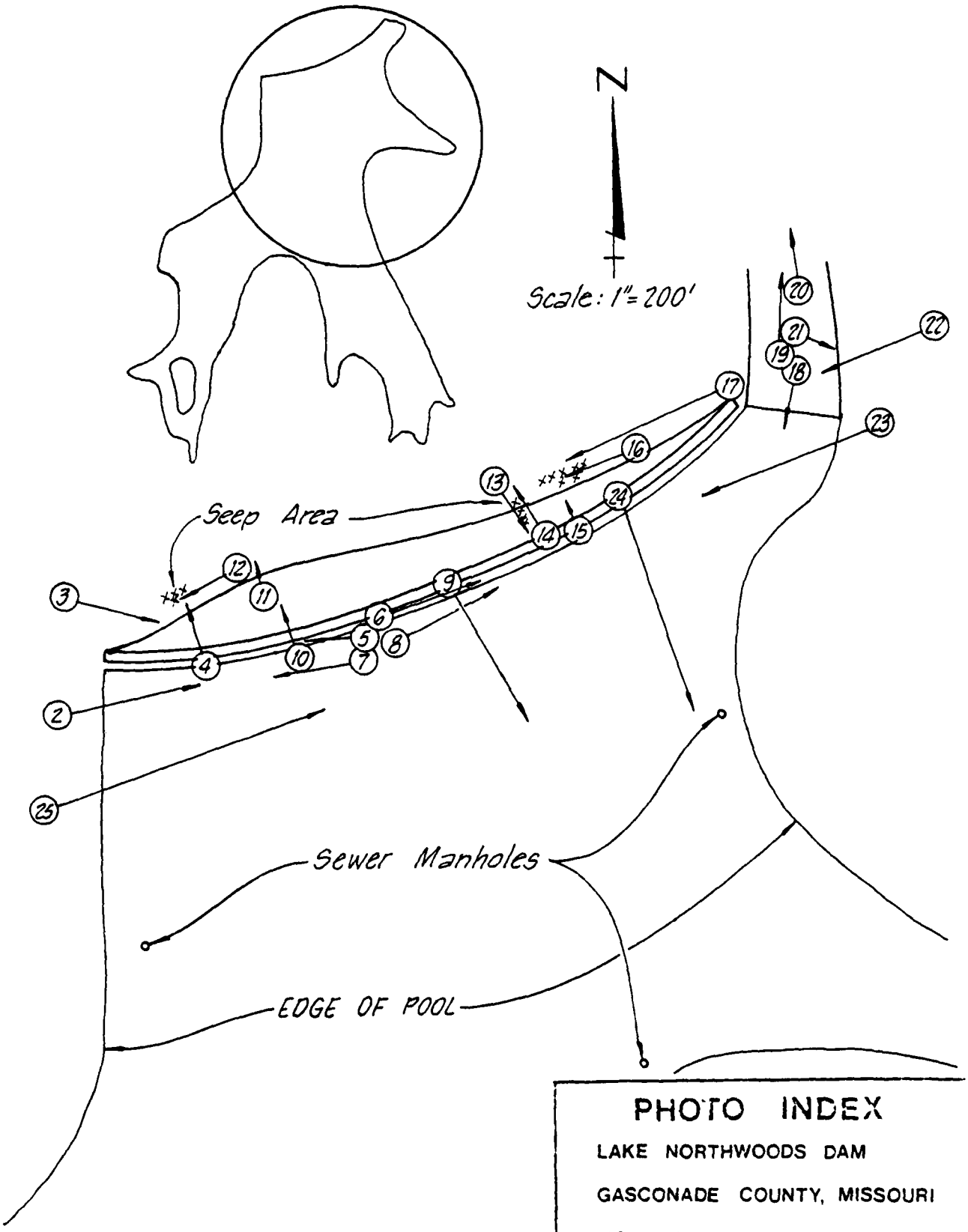


PHOTO INDEX

LAKE NORTHWOODS DAM

GASCONADE COUNTY, MISSOURI

MO. 30110

PLATE B-1

PHOTO NO. 2 - UPSTREAM SLOPE FROM LEFT ABUTMENT

PHOTO NO. 3 - DOWNSTREAM SLOPE FROM LEFT ABUTMENT

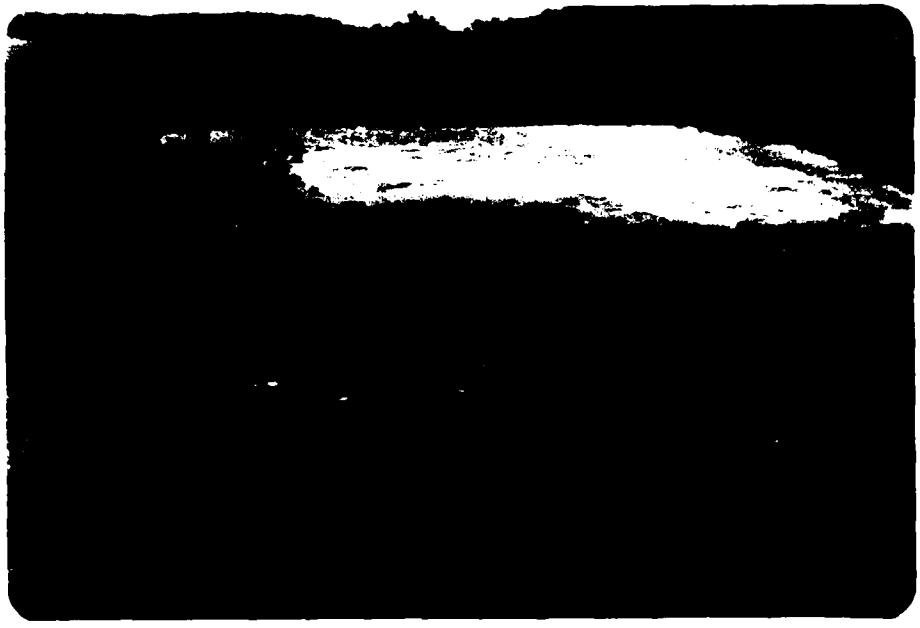


PHOTO NO. 4 - SEEP AREA DOWNSTREAM FROM STA. 1 + 00.
SEWAGE LAGOON IN BACKGROUND.

PHOTO NO. 5 - CREST FROM STA. 6 + 00 LOOKING TOWARD
LEFT ABUTMENT

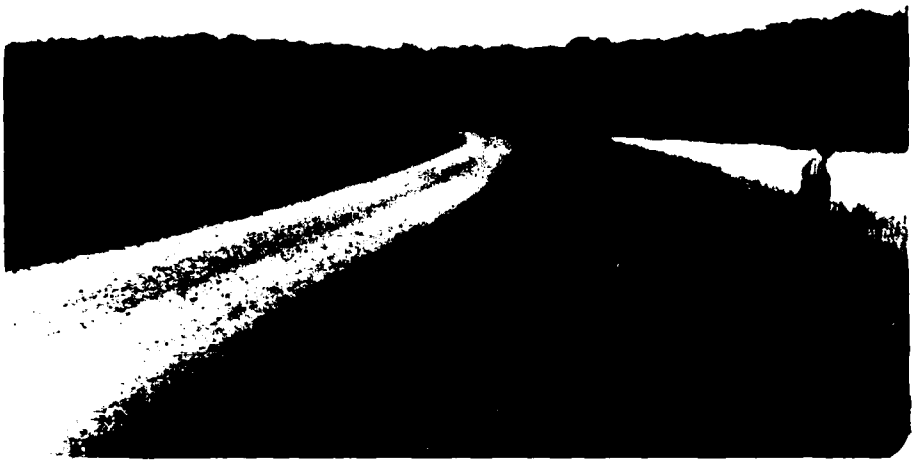


PHOTO NO. 6 - CREST FROM STA. 6 + 00 LOOKING TOWARD RIGHT ABUTMENT

PHOTO NO. 7 - UPSTREAM SLOPE FROM STA. 6 + 00 LOOKING TOWARD THE LEFT ABUTMENT

PHOTO NO. 8 - UPSTREAM SLOPE FROM STA. 6 + 00 LOOKING TOWARD THE RIGHT ABUTMENT

PHOTO NO. 9 - UPSTREAM ACROSS LAKE FROM STA. 5 + 50

PHOTO NO. 10 - DOWNSTREAM FROM STA. 3 + 00. PONDED WATER AT LOWER LEFT IS AT OUTLET OF DRAWDOWN PIPE

PHOTO NO. 11 - VALVE AT END OF DRAWDOWN PIPE

PHOTO NO. 12 - LEFT ABUTMENT SEEP AREA AT STA. 1 + 00

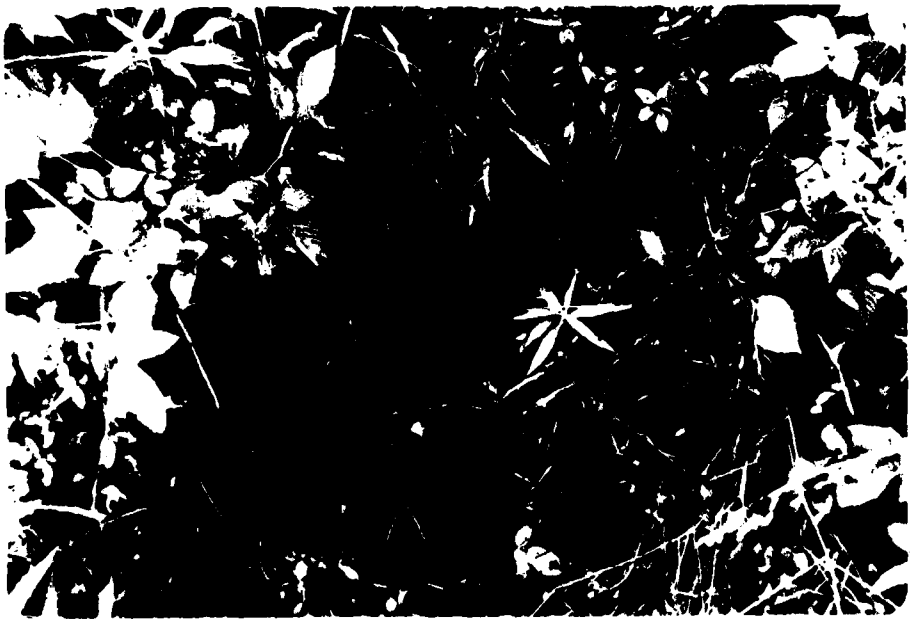


PHOTO NO. 13 - OUTLET END OF 6 INCH CAST IRON SEWER

PHOTO NO. 14 - DOWNSTREAM SLOPE EAST FROM STA. 5 + 00.
SEWER OUTLETS NEAR CENTER OF PHOTO.

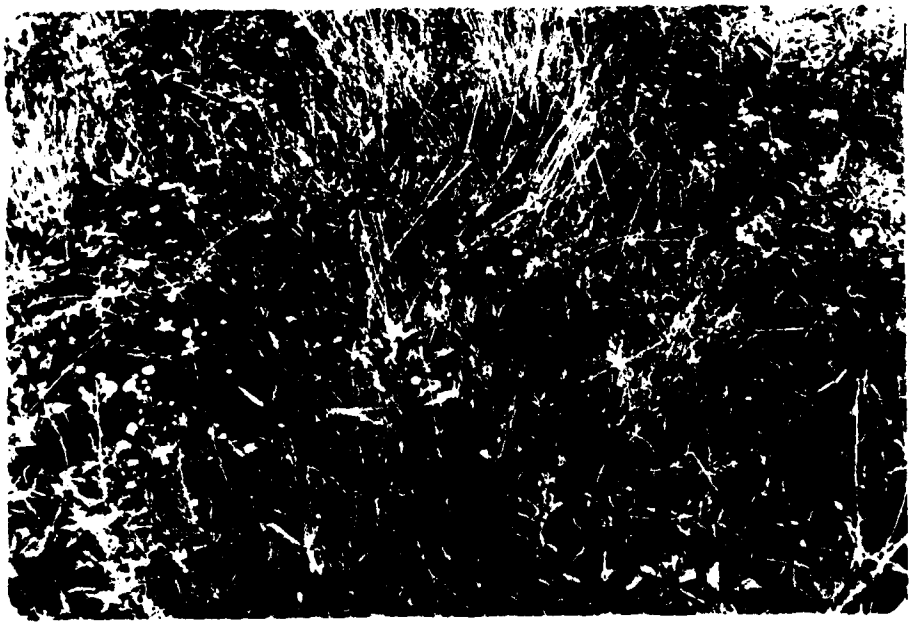


PHOTO NO. 15 - GULLIES IN DOWNSTREAM SLOPE OF ABUTMENT

PHOTO NO. 16 - SEEP AREA IN RIGHT ABUTMENT TROUGH FROM STA. 9 + 50 to 10 + 00

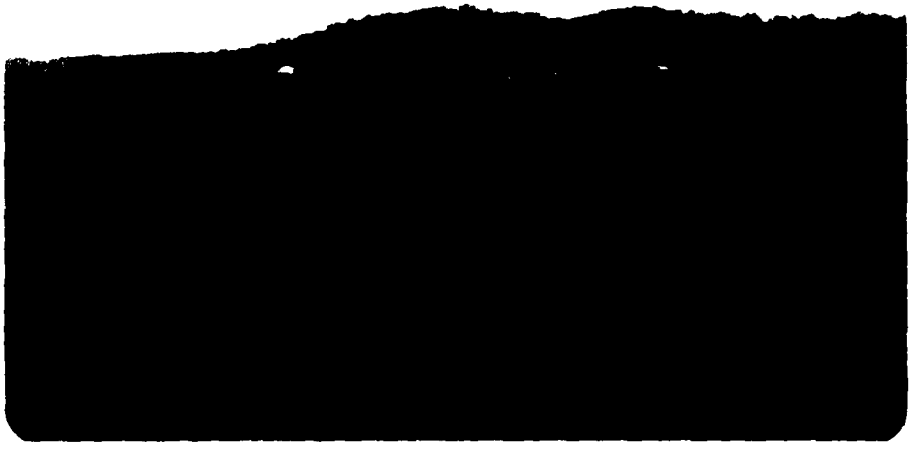


PHOTO NO. 17 - DOWNSTREAM SLOPE TAKEN FROM RIGHT ABUTMENT

PHOTO NO. 18 - LOOKING UPSTREAM IN SPILLWAY

PHOTO NO. 19 - LOOKING DOWNSTREAM IN SPILLWAY

PHOTO NO. 20 - EXIT CHANNEL FOR SPILLWAY

PHOTO NO. 21 - ROCK OUTCROPS IN RIGHT SIDE OF SPILLWAY

PHOTO NO. 22 - CREST AND DOWNSTREAM SLOPE WITH SPILLWAY IN FOREGROUND

PHOTO NO. 23 - UPSTREAM SLOPE TAKEN FROM UPSTREAM OF RIGHT END

PHOTO NO. 24 - UPSTREAM FROM STA. 12 + 00. SEWER MANHOLE AT LEFT CENTER. TWO OTHERS BARELY VISIBLE.

PHOTO NO. 25 - OVERVIEW FROM HIGH ON LEFT ABUTMENT

APPENDIX C
PROJECT PLATES

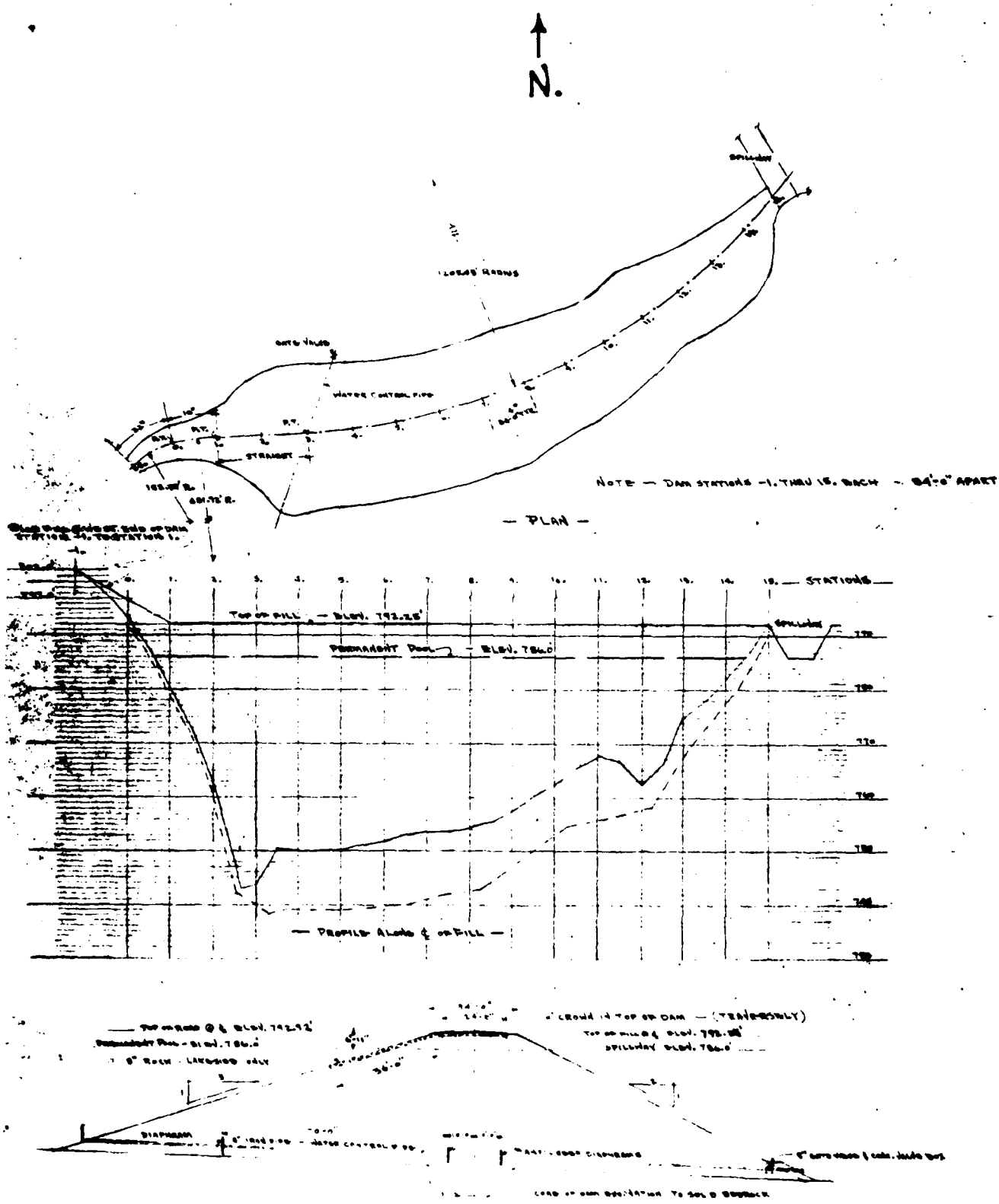

N.
NOTE — DAM STATIONS -1. THRU 15. EACH - 84'-0" APART
— PLAN —
STATIONS
— PROFILE ALONG ℄ OF FILL —
— SECTION —

PLATE C-1

LAKE NORTHWOODS

— EARTH FILL DAM —

LENGTH — [illegible]
PERMANENT POOL ELEV. — 700.0
TOP OF DAM ELEV. — 709.0' (INCLUDING PAVED ROAD)
WIDTH OF CREST — 24'
CORE WIDTH — 12'
CORE EXCAVATION — APPROX. 300 CUBIC YARDS = 300 CU.YDS. EARTH
EARTH FILL FOR DAM — [illegible] CU.YDS. (COMPACTED)

— SPILLWAY —

LENGTH —
WIDTH — 40'
ELEVATION — 700.0
EXCAVATION — ROCK - APPROX. 1000 CU.YDS.
— EARTH - APPROX. 1200 CU.YDS.

NOTE — [illegible] INCLUDING FILL FOR PAVED ROAD ON CREST OF DAM.

— SPECIFICATIONS —
WATER CONTROL PIPING

MATERIAL —
1. 240 LINEAL FEET - 8" DIA. (ALL PIPING SCHEDULE 40 BLACK STEEL)
2. THREADED [illegible] FITTINGS FOR ALL PIPING UNLESS OTHERWISE NOTED.
3. 1 - 8 FOOT STANDPIPE WITH ELBOW & CAP - 8"
4. 1 - REDUCER, 8" TO 6" WITH FLANGED FITTING ON 1½ END FOR CONNECTION TO GATE VALVE.
5. 1 - 6 FOOT DISCHARGE PIPE WITH FLANGED FITTING 1) - END & THREADED 1) - END — 6"
6. 1 - 8" GATE VALVE WITH FLANGED FITTINGS — (FURNISHED BY OWNER)
7. 3 - 8" [illegible] ELL - [illegible] - 3 [illegible]
8. COATING: BITUMASTIC NO. 50 - COAL TAR PRIMER - 48 GALS. REQ.
9. CONCRETE [illegible]

NOTE — ALL [illegible] SHALL BE PROTECTED AGAINST DAMAGE TO PIPING DURING THE CONSTRUCTION. PAINT OUTSIDE OF [illegible] ALL EXPOSED PIPING AND FITTINGS WITH 2 COATS OF BITUMINOUS COATING WITH BRUSH OR BITUMINOUS MASTIC (APPLY WITH BRUSH)

INSTALLATION —
1. EXCAVATE TRENCHES NECESSARY TO INSTALL PIPING TO LIE ON A STRAIGHT LINE AND PITCH ON A STRAIGHT GRADE.
2. ALL PIPING SHALL LIE ON COMPACTED SOIL.
3. WELD PIPING AS MUCH AS ELECTRICALLY POSSIBLE.
4. BACKFILL PIPE TRENCHES AND BACKFILL BY HAND AND COMPACT SUITABLE HAND COMPACTION EQUIPMENT, AS NECESSARY OR USED.
5. USE FITTINGS, CAPS WHERE SHOWN & CONNECTIONS ARE PIPING.
6. STANDPIPE, REDUCER, GATE VALVE & DISCHARGE PIPE SHALL NOT BE INSTALLED UNTIL FILL OF DAM HAS REACHED 8' OF ITS HEIGHT TO ALLOW SHRINK.
7. CONTRACTOR SHALL VISIT SITE FOR PURPOSE OF COST ESTIMATE FOR INSTALLATION.

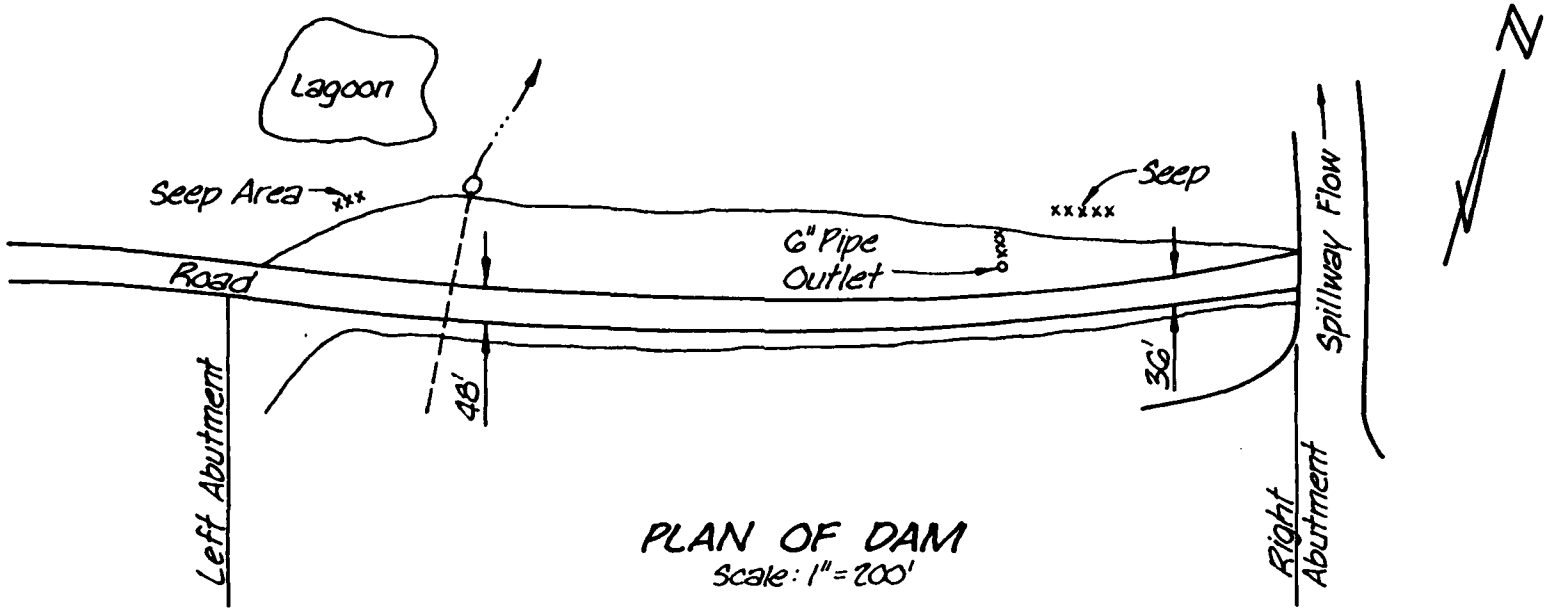
NOTE — AT TOP OF STANDPIPE, 6" HOLE SHALL BE DRILLED TO ALLOW FULL FLOW OF WATER THRU PIPING.

— PAVED ROAD —

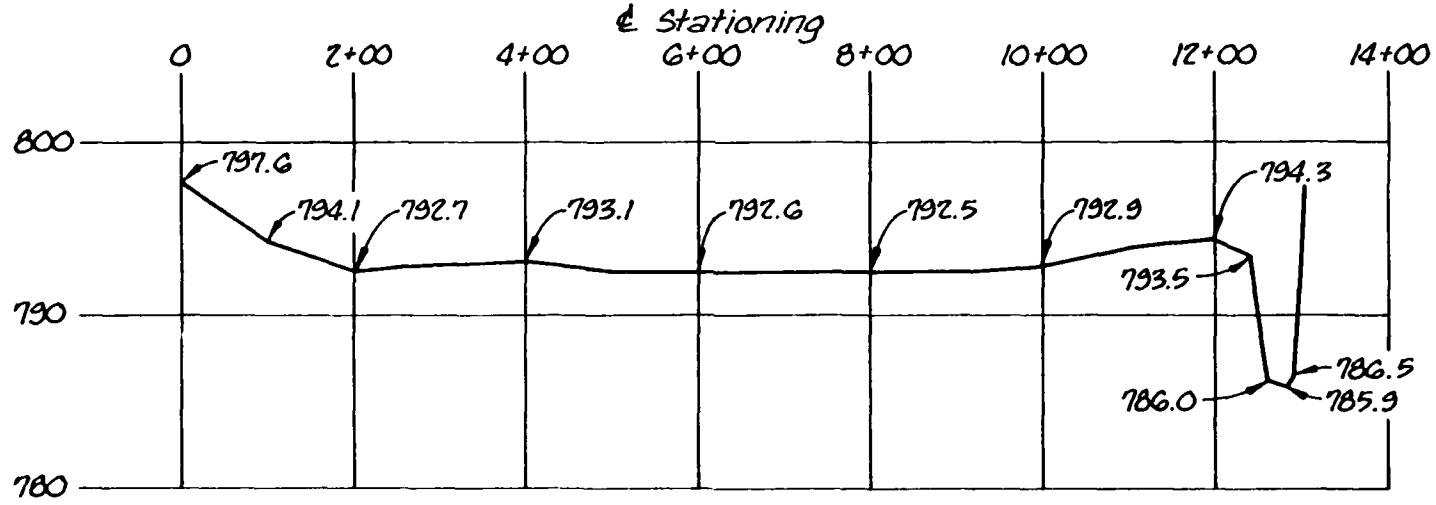
1. PAVED ROAD ACROSS DAM SHALL BE 8" THICK, 24' WIDE & SHALL EXTEND FROM DAM STATION -4+70 TO STATION 1+15.
2. SUBGRADE SHALL BE MADE IN TWO LIFTS OF 4" EACH.
3. FIRST 4" — OF 2" CLEAN STONE CHOKED DOWN WITH 1" MINUS STONE & ROLLED WITH 10-TON ROLLER.
4. SECOND 4" — OF 1½" MINUS STONE SPREAD, [illegible] & ROLLED & ½" CHAT SPREAD EVENLY ON TOP.
5. WATERBOUND & ROLLED WITH 10-TON ROLLER.
6. TACK COAT SHALL BE ½ GAL. PER SQ.YD. OF RC-2 CUTBACK ASPHALT PENETRATION ALLOW TRAFFIC OVER & TOP.
7. TWO SEAL COATS EACH OF ½ GAL. PER SQ.YD. OF RC-2 CUTBACK ASPHALT.
8. SPREAD 25 LBS. PER SQ.YD. OF 3/8" PEA GRAVEL & ROLL.

NORTH WOODS ESTATES INC. LAKE DEVELOPMENT ELDON, OSAGE VILLE MISSOURI		DATE Oct. 21 1960
SCALE: H		D-1
DET.	SHEET 1	1 OF 1 SHEETS

PLATE C-2

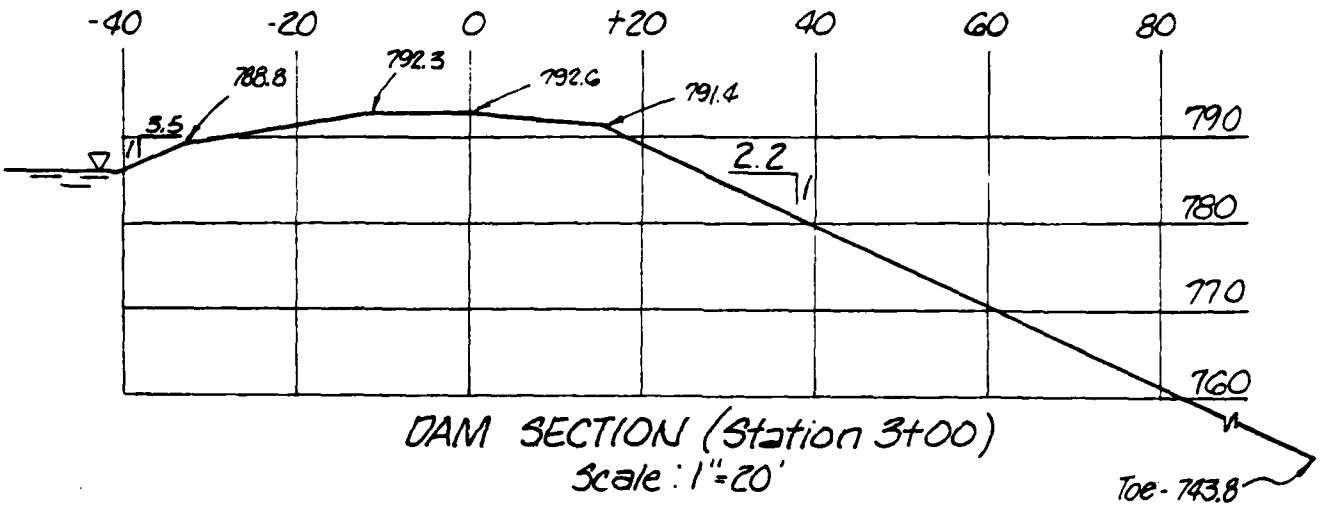


PLAN OF DAM
Scale: 1" = 200'

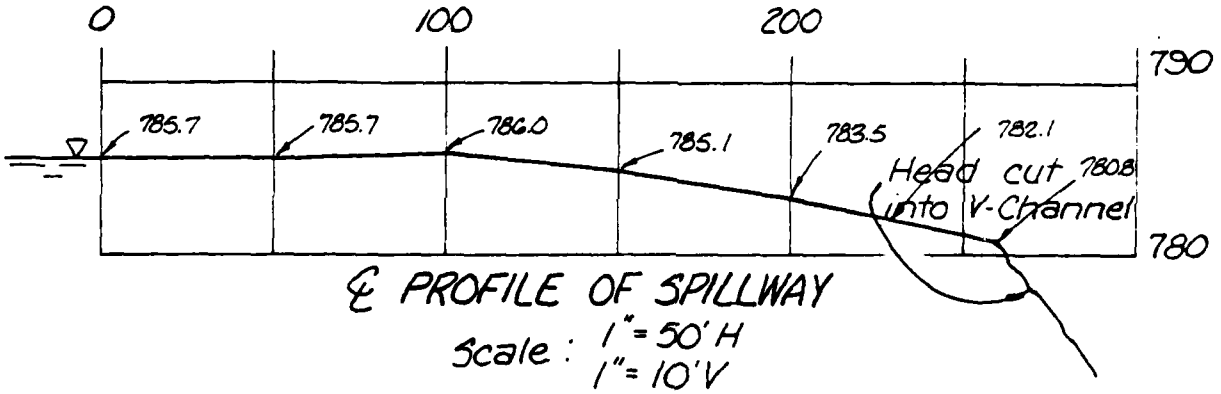


PROFILE ALONG CENTERLINE OF DAM
Scale: 1" = 200' H.
1" = 10' V.

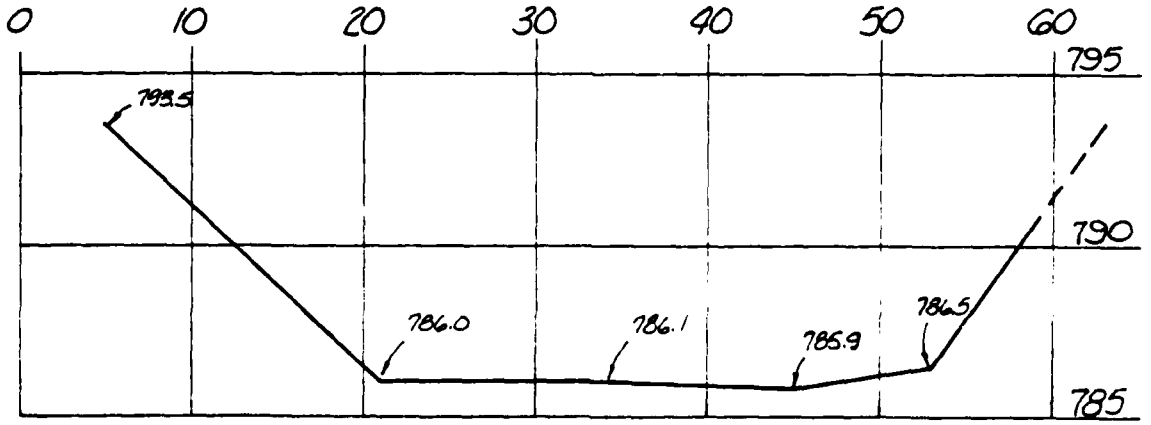
PLATE C-3



DAM SECTION (Station 3+00)
Scale: 1"=20'



℄ PROFILE OF SPILLWAY
Scale: 1"=50' H
1"=10' V



SPILLWAY SECTION on DAM ℄
Scale: 1"=10' H
1"=5' V

PLATE C-4

Eng Geol. Reservoir

GEOLOGIC REPORT ON THE NORTHWOODS LAKESITE, GASCONADE COUNTY

The site proposed for a lake on a tributary to Second Creek is located in the SE¼ SE¼ NE¼ sec. 33, T.43 N., R.5 W. (Gerald Quadrangle). Bedrock in this area is the Jefferson City Formation. It is firm, evenly bedded, and is water tight with the exception of some near surface weathered zones which are of minor importance. This setting for a lake is excellent geologically and no serious water loss hazards into bedrock or through permeable soils are anticipated with one exception. The possibility of a permeable gravel layer in the lower portion of the valley alluvial soils should be explored preferably with several deep holes dug by a backhoe.

Construct 1 (K-2)

The dam site is in an area where the abutment slopes are gentle and the valley is relatively broad. A dam at this location may not encounter bedrock either on the abutment slopes or on the valley floor. It will be necessary to explore this setting with a backhoe or possibly a power driven rotary auger to determine depth to bedrock. However, if the dam is moved upstream slightly (NE¼ SE¼ NE¼ sec. 33) and this is recommended from the geological aspect, the left (west) abutment slope will be relatively steep. Therefore, the abutment core trench can be cut into firm fresh bedrock. In addition the right abutment slope is somewhat steeper and it may be possible to reach bedrock in the right abutment core. If the abutment of the dam can be seated on bedrock it is strongly recommended that the core trench be ripped into firm fresh bedrock. This can best be accomplished by a back mounted ripper on a large caterpillar. Failure to remove all loose weathered bedrock in the core trench increases the possibility of serious water seepage through the core trench. If it is economically feasible, the core trench should also be cut to bedrock across the valley floor. However, this cannot be determined until some exploration pits have been dug.

It is anticipated that the lower portion of the valley alluvium especially near the underlying bedrock will consist of permeable water saturated gravel. It is important that these water bearing gravels if they are present are intercepted by a well compacted relatively water tight core trench. However, if this cannot be accomplished within practical economic means it is then recommended that the area immediately upstream of the damsite is not disturbed by borrow excavation. If there is any possibility that water bearing gravels are not cut off in the core trench of the dam any water leakage in the lake upstream of the dam would be lost relatively rapidly by underflow under the dam. Consequently, it is most important that the lower portion of the valley alluvium of presently suitable soils for water impoundment should not be disturbed. This material would act as a natural pad to retard the rate of seepage from the lake into underlying gravels. Consequently, the borrow areas should be restricted to the valley slopes and farther upstream where the possibility of water seepage into underlying gravels would be much less hazardous. In addition, if the core trench cannot be cut to bedrock, it will be necessary to pad the stream channel for a short distance upstream of the dam.

The site is recommended geologically for a lake. A relatively stable waterline should be maintained during normal rainfall seasons. The precautions

of seepage into underlying gravel is the one important hazard which should be explored during preconstruction studies.

James H. Williams

James H. Williams
Engineering Geologist
Missouri Geological Survey
January 12, 1966

PLATE C-6

APPENDIX D
HYDRAULIC AND HYDROLOGIC DATA

HYDROLOGIC COMPUTATIONS

1. The SCS dimensionless unit hydrograph and the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Corps of Engineers, Davis, California, were used to develop the inflow hydrographs (see this Appendix).

   a. Twenty-four hour, 100-year rainfall for the dam location was taken from the data for the rainfall station at Sullivan, MO. as supplied by the St. Louis District, Corps of Engineers per their letter dated 6 March 1979. The twenty-four hour probable maximum precipitation was taken from the curves of Hydrometeorological Report No. 33 and current Corps of Engineers and St. Louis policy and guidance for hydraulics and hydrology.

   b. Drainage area = 1.61 square miles (1,029 acres).

   c. Time of concentration of runoff = 23 minutes (computed from "Kirpich" formula).

   d. The antecedent storm conditions for the probable maximum precipitation were heavy rainfall and low temperatures which occurred on the previous 5 days (SCS AMC III). The antecedent storm conditions for the 100-year precipitation were an average of the conditions which have preceded the occurrence of the maximum annual flood on numerous watersheds (SCS AMC II). The initial pool elevation was assumed at the crest of the spillway.

   e. The total twenty-four hour storm duration losses for the 100-year storm were 3.84 inches. The total losses for the PMF storm were 2.50 inches. These data are based on SCS runoff curve No. 82 and No. 66 for antecedent moisture conditions SCS AMC III and AMC II respectively. The watershed is composed of primarily SCS soil group B, C and D (Goss - 40%, Union - 50%, and Gerald - 10% respectively) and consists mostly of wooded area with a small percentage of cropland.

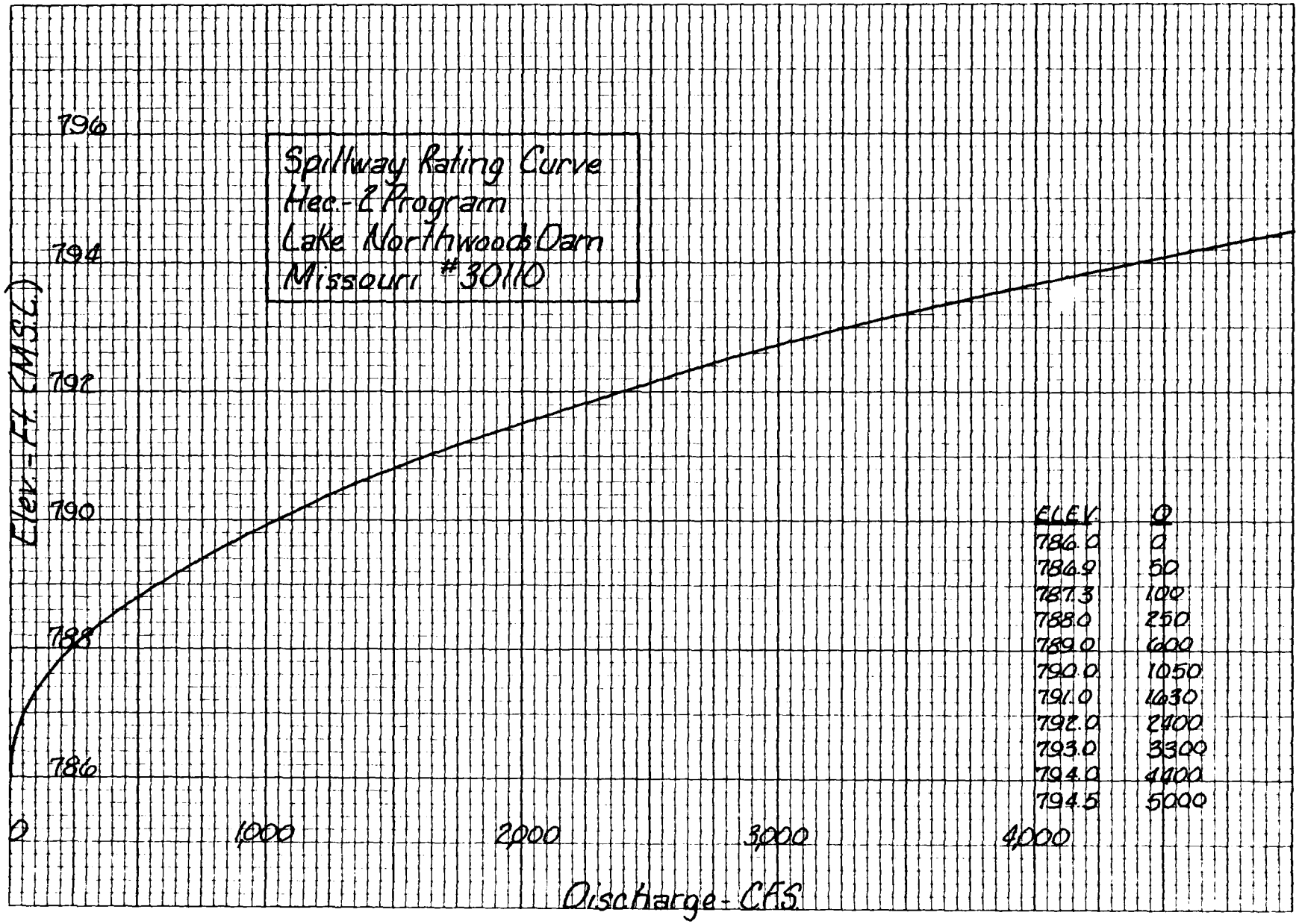
f. Average soil loss rates = 0.10 inch per hour approximately.

2. The spillway discharge rating was developed using the Corps of Engineers Surface Water Profile HEC-2 computer program.

   The flows over the dam crest were developed using the HEC-1 (Dam Safety Version) program with a discharge coefficient of 2.9 and a value of 1.5 for the exponent of head.

3. Floods were routed through the reservoir using the HEC-1 (Dam Safety Version) program to determine the capabilities of the spillway and dam embankment crest. The output and plotted hydrographs are shown in this Appendix.

10 X 10 PER INCH



ELEV.	Q
786.0	0
786.9	50
787.3	100
788.0	250
789.0	600
790.0	1050
791.0	1630
792.0	2400
793.0	3300
794.0	4400
794.5	5000

PLATE D-3

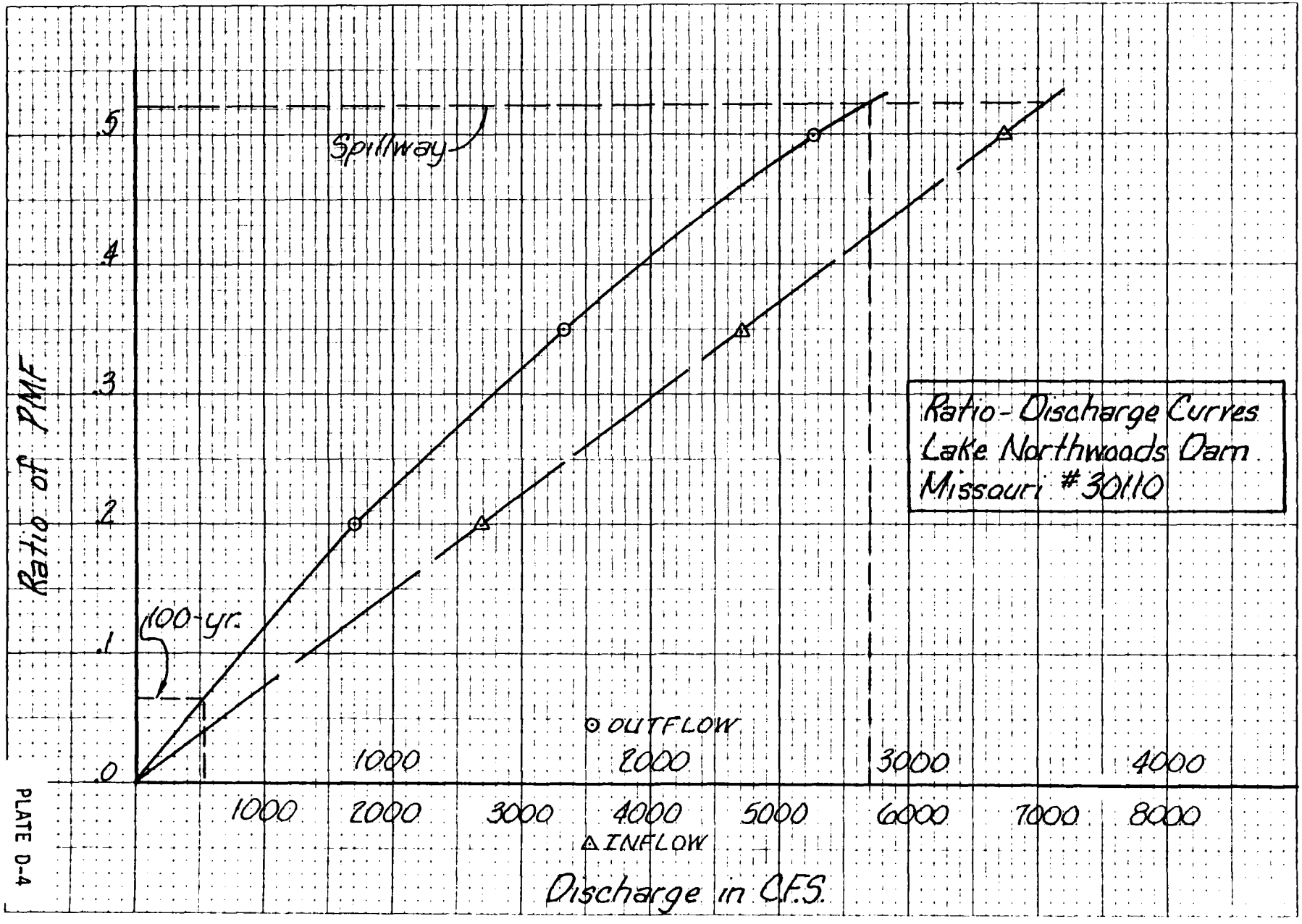


PLATE D-4

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A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF LAKE NORTHWOODS DAM 30110
A3       RATIOS OF PMF ROUTED THROUGH THE RESERVOIR
B 0002800000300000000005 0000000000000000000000003
B1000005
J 000001000000600000001
J1000.2000000.3500000.5000000.6500000.80000001.0
K 000000000000301 0000000200000000000000001
K1       CALCULATION OF INFLOW HYDROGRAPH TO RES 30110
M 000001000000200001.61 00001.61000001.0 00000001
P        000025.4000601020000012100000130
T                                          -1.0   -82.0
M2       00000.38
X 000000    -.0100000001
K 000001000000302 0000000200000000000000001
K1       ROUTED FLOWS THRU RES 30110
Y                    0000000100000001
Y1000001                                  -786.0      -1
Y4786.0000786.0000787.0000788.0000789.0000790.0000791.0000792.0000793.0000794.0
Y40794.5
Y500000000000050000001000000025000000600000010500000163000002400000033000000440O
Y5005000
$S000000000000300000038100000327000008440000167000002860
$E0307450000075000000760000007700000078000000790000000800
$S0786.0
$D3792.5000092.9000001.500001272
$L0004503000006400000085000000920000010100000108200001100000001272
SY0792.7000792.9000793.1000793.5000793.9000794.1000794.3000795.0
K 000099
A
A
A
A
A
```

PLATE D-5

****
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 26 FEB 79
****

RUN DATE= 79/07/25.
TIME= 15.48.02.

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF LAKE NORTHWOODS DAM 30110
RATIOS OF PMF ROUTED THROUGH THE RESERVOIR

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	5	0	0	0	0	0	3	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 6 LRTIO= 1
RTIOS= .20 .35 .50 .65 .80 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

CALCULATION OF INFLOW HYDROGRAPH TO RES 30110

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
000001	0	0	0	2	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	1.61	0.00	1.61	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.40	102.90	121.00	130.00	0.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-82.00	0.00	0.00

CURVE NO = -82.00 WETNESS = -1.00 EFFECT CN = 82.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .38

RECESSION DATA
STRTQ= 0.00 QRCSN= -.01 RTIOR= 1.00

UNIT HYDROGRAPH 25 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .38 VOL= 1.00

181.	561.	1193.	1697.	1843.	1732.	1464.	1075.	747.	539.
400.	287.	209.	151.	109.	79.	58.	42.	30.	22.
17.	13.	8.	5.	1.					

UV%

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 1

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2692.	864.	263.	263.	75790.
CMS	76.	24.	7.	7.	2146.
INCHES		4.99	6.08	6.08	6.08
MM		126.81	154.48	154.48	154.48
AC-FT		428.	522.	522.	522.
THOUS CU M		528.	644.	644.	644.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 2

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4710.	1512.	461.	461.	132632.
CMS	133.	43.	13.	13.	3756.
INCHES		8.74	10.64	10.64	10.64
MM		221.91	270.34	270.34	270.34
AC-FT		750.	913.	913.	913.
THOUS CU M		925.	1127.	1127.	1127.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 3 0.5 PMP

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	6729.	2160.	658.	658.	189474.
CMS	191.	61.	19.	19.	5365.
INCHES		12.48	15.20	15.20	15.20
MM		317.02	386.20	386.20	386.20
AC-FT		1071.	1305.	1305.	1305.
THOUS CU M		1321.	1610.	1610.	1610.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 4

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	8748.	2808.	855.	855.	246317.
CMS	248.	80.	24.	24.	6975.
INCHES		16.23	19.77	19.77	19.77
MM		412.12	502.07	502.07	502.07
AC-FT		1392.	1696.	1696.	1696.
THOUS CU M		1718.	2092.	2092.	2092.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 5

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	10766.	3456.	1053.	1053.	303159.
CMS	305.	98.	30.	30.	8585.
INCHES		19.97	24.33	24.33	24.33
MM		507.23	617.93	617.93	617.93
AC-FT		1714.	2088.	2088.	2088.
THOUS CU M		2114.	2575.	2575.	2575.

HYDROGRAPH AT STA000001 FOR PLAN 1, RATIO 6 [PMF]

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	13458.	4320.	1316.	1316.	378949.
CMS	381.	122.	37.	37.	10731.
INCHES		24.96	30.41	30.41	30.41
MM		634.04	772.41	772.41	772.41
AC-FT		2142.	2610.	2610.	2610.
THOUS CU M		2642.	3219.	3219.	3219.

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTED FLOWS THRU RES 30110

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
000002	1	0	0	2	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-786.	-1

STAGE	786.00	786.90	787.30	788.00	789.00	790.00	791.00	792.00	793.00	794.00
	794.50									
FLOW	0.00	50.00	100.00	250.00	600.00	1050.00	1630.00	2400.00	3300.00	4400.00
	5000.00									
CAPACITY=	0.	7.	81.	327.	844.	1670.	2860.			
ELEVATION=	745.	750.	760.	770.	780.	790.	800.			

CREL	SPWID	COQW	EXPW	ELEVL	COOL	CAREA	EXPL
786.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
792.5	2.9	1.5	1272.

CREST LENGTH	450.	640.	850.	920.	1010.	1082.	1108.	1272.
AT OR BELOW ELEVATION	792.7	792.9	793.1	793.5	793.9	794.1	794.3	795.0

STATION 000002, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	1.	1.	1.

PLATE D-8

DVN

STATION 000002, PLAN 1, RATIO 6 PMF

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	1.	1.	1.	1.	1.	1.	1.	1.	1.
2.	2.	2.	2.	2.	2.	2.	3.	3.	3.
3.	3.	4.	4.	4.	5.	5.	6.	7.	8.
10.	11.	13.	14.	16.	18.	20.	22.	24.	26.
29.	31.	33.	35.	38.	40.	43.	45.	48.	50.
56.	62.	68.	73.	79.	85.	91.	96.	104.	114.
123.	133.	142.	152.	161.	171.	180.	189.	198.	207.
215.	224.	233.	241.	250.	263.	276.	289.	301.	313.
325.	337.	349.	360.	371.	381.	392.	402.	412.	421.
431.	440.	449.	458.	467.	477.	490.	509.	534.	566.
604.	657.	713.	770.	828.	886.	943.	1000.	1056.	1108.
1161.	1216.	1271.	1326.	1381.	1435.	1489.	1541.	1592.	1647.
1714.	1783.	1854.	1927.	2002.	2077.	2152.	2225.	2296.	2366.
2438.	2512.	2580.	2646.	2716.	2803.	2936.	3222.	4115.	5746.
7682.	9393.	10426.	10661.	10277.	9567.	8757.	7970.	7270.	6662.
6149.	5723.	5373.	5086.	4850.	4652.	4479.	4320.	4170.	4027.
3894.	3774.	3669.	3578.	3505.	3442.	3385.	3327.	3258.	3170.
3071.	2986.	2897.	2798.	2694.	2588.	2482.	2381.	2294.	2208.
2126.	2045.	1968.	1894.	1822.	1754.	1688.	1626.	1580.	1536.
1493.	1452.	1411.	1373.	1335.	1299.	1264.	1230.	1197.	1165.
1135.	1105.	1076.	1049.	1019.	990.	962.	935.	910.	885.
861.	838.	816.	794.	774.	754.	735.	717.	700.	683.
666.	651.	635.	621.	607.	595.	584.	574.	564.	555.
546.	537.	528.	520.	512.	504.	496.	489.		

STORAGE

1340.	1340.	1340.	1340.	1340.	1340.	1340.	1340.	1340.	1340.
1340.	1340.	1340.	1340.	1340.	1340.	1340.	1340.	1340.	1340.
1340.	1340.	1340.	1340.	1340.	1340.	1340.	1340.	1340.	1340.
1340.	1340.	1340.	1340.	1340.	1340.	1340.	1340.	1340.	1340.
1340.	1340.	1340.	1340.	1340.	1340.	1340.	1340.	1340.	1340.
1340.	1340.	1341.	1341.	1341.	1341.	1341.	1341.	1342.	1342.
1342.	1342.	1342.	1343.	1343.	1343.	1343.	1344.	1344.	1344.
1344.	1345.	1345.	1345.	1346.	1346.	1347.	1349.	1350.	1352.
1354.	1356.	1359.	1361.	1364.	1367.	1370.	1373.	1376.	1379.
1382.	1385.	1389.	1392.	1396.	1399.	1403.	1407.	1410.	1414.
1418.	1422.	1426.	1429.	1433.	1437.	1441.	1445.	1448.	1452.
1456.	1460.	1463.	1467.	1471.	1474.	1478.	1481.	1485.	1488.
1491.	1495.	1498.	1501.	1505.	1508.	1511.	1514.	1517.	1520.
1523.	1525.	1528.	1531.	1533.	1536.	1538.	1541.	1543.	1545.
1547.	1550.	1552.	1554.	1556.	1558.	1561.	1566.	1572.	1579.
1588.	1598.	1608.	1619.	1629.	1640.	1650.	1661.	1671.	1682.
1693.	1704.	1715.	1727.	1738.	1749.	1760.	1771.	1781.	1792.
1802.	1813.	1824.	1835.	1846.	1858.	1870.	1881.	1892.	1903.
1913.	1923.	1932.	1941.	1950.	1961.	1979.	2007.	2047.	2074.
2138.	2171.	2189.	2193.	2186.	2174.	2159.	2144.	2130.	2116.
2104.	2094.	2085.	2077.	2070.	2064.	2059.	2054.	2049.	2044.
2039.	2035.	2031.	2027.	2023.	2020.	2017.	2014.	2009.	2003.
1996.	1985.	1974.	1961.	1947.	1933.	1919.	1905.	1892.	1878.
1866.	1853.	1841.	1830.	1819.	1808.	1798.	1788.	1779.	1770.

PLATE D-9

```
   1761.      1752.      1744.      1736.      1720.      1721.      1714.      1707.      1700.      1694.
   1687.      1681.      1675.      1670.      1664.      1659.      1654.      1649.      1644.      1640.
   1635.      1631.      1627.      1623.      1619.      1616.      1612.      1609.      1606.      1603.
   1600.      1597.      1594.      1591.      1589.      1586.      1584.      1581.      1579.      1577.
   1575.      1573.      1570.      1569.      1567.      1565.      1563.      1561.

                                           STAGE
   786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0
   786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0
   786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0
   786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0
   786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0
   786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0
   786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.0      786.1      786.1
   786.1      786.1      786.1      786.1      786.1      786.1      786.1      786.1      786.1      786.2
   786.2      786.2      786.2      786.3      786.3      786.3      786.4      786.4      786.4      786.5
   786.5      786.6      786.6      786.6      786.7      786.7      786.8      786.8      786.9      786.9
   786.9      787.0      787.0      787.1      787.1      787.2      787.2      787.3      787.3      787.4
   787.4      787.5      787.5      787.5      787.6      787.6      787.7      787.7      787.8      787.8
   787.8      787.9      787.9      788.0      788.0      788.0      788.1      788.1      788.1      788.2
   788.2      788.2      788.3      788.3      788.3      788.4      788.4      788.4      788.5      788.5
   788.5      788.5      788.6      788.6      788.6      788.6      788.7      788.7      788.8      788.9
   789.0      789.1      789.3      789.4      789.5      789.6      789.8      789.9      790.0      790.1
   790.2      790.3      790.4      790.5      790.6      790.7      790.8      790.8      790.9      791.0
   791.1      791.2      791.3      791.4      791.5      791.6      791.7      791.8      791.9      792.0
   792.0      792.1      792.2      792.3      792.4      792.4      792.6      792.8      793.2      793.6
   793.9      794.2      794.4      794.4      794.3      794.2      794.1      794.0      793.9      793.8
   793.7      793.6      793.5      793.4      793.4      793.3      793.3      793.2      793.2      793.1
   793.1      793.1      793.0      793.0      793.0      792.9      792.9      792.9      792.9      792.8
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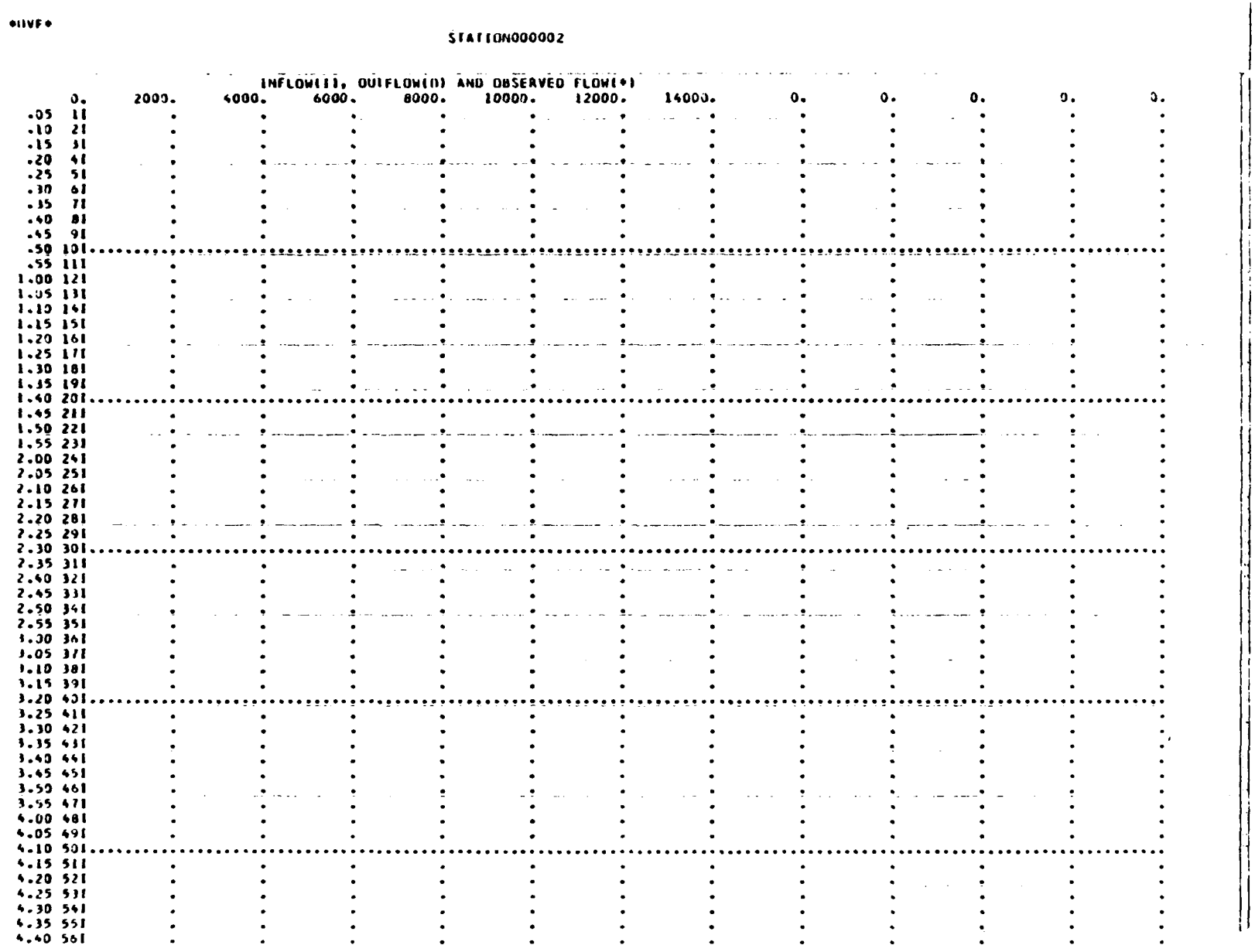
   790.1      790.1      790.0      790.0      789.9      789.9      789.8      789.7      789.7      789.6
   789.6      789.5      789.5      789.4      789.4      789.3      789.3      789.3      789.2      789.2
   789.1      789.1      789.1      789.0      789.0      789.0      789.0      788.9      788.9      788.9
   788.8      788.8      788.8      788.8      788.7      788.7      788.7      788.7

PEAK OUTFLOW IS     10661. AT TIME   16.17 HOURS

                                  PEAK     6-HOUR    24-HOUR    72-HOUR   TOTAL VOLUME
                        CFS     10661.      3782.      1204.      1204.        346870.
                        CMS       302.       107.        34.        34.          9822.
                     INCHES                 21.85      27.84      27.84          27.84
                         MM                555.00     707.02     707.02         707.02
                      AC-FT                 1875.      2389.      2389.          2389.
                 THOUS CU M                 2313.      2947.      2947.          2947.
```


HYP
STATION000002
INFLOW(I), OUTFLOW(O) AND OBSERVED FLOW(*)
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.05 1I
.10 2I
.15 3I
.20 4I
.25 5I
.30 6I
.35 7I
.40 8I
.45 9I
.50 10I
.55 11I
1.00 12I
1.05 13I
1.10 14I
1.15 15I
1.20 16I
1.25 17I
1.30 18I
1.35 19I
1.40 20I
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1.50 22I
1.55 23I
2.00 24I
2.05 25I
2.10 26I
2.15 27I
2.20 28I
2.25 29I
2.30 30I
2.35 31I
2.40 32I
2.45 33I
2.50 34I
2.55 35I
3.00 36I
3.05 37I
3.10 38I
3.15 39I
3.20 40I
3.25 41I
3.30 42I
3.35 43I
3.40 44I
3.45 45I
3.50 46I
3.55 47I
4.00 48I
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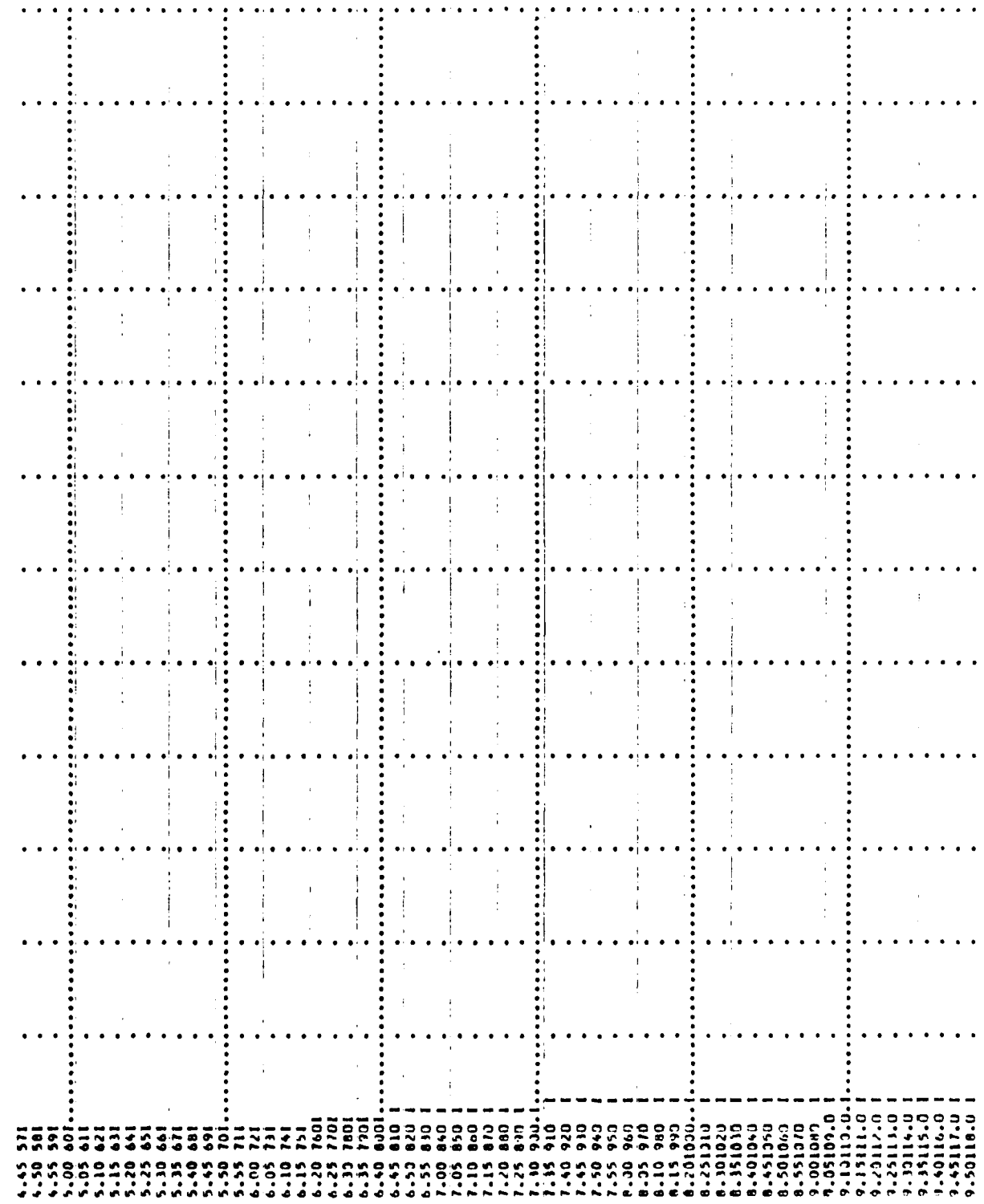
PLATE D-11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5.40 681
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5.55 711
6.00 721
6.05 731
6.10 741
6.15 751
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6.55 830
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PLATE D-12

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PLATE D-13

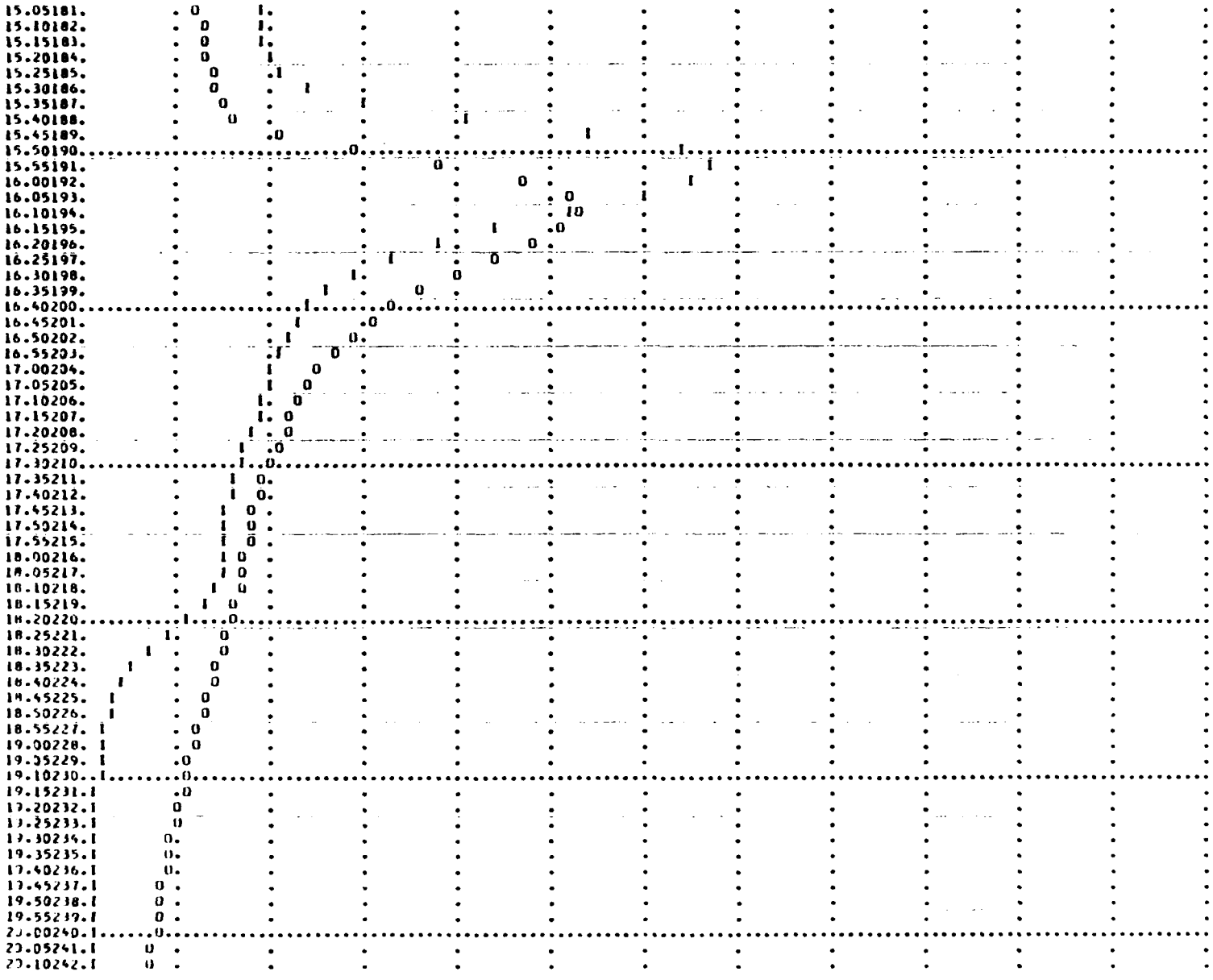
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PLATE D-14

PLATE D-15

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .20	RATIO 2 .35	RATIO 3 .50	RATIO 4 .65	RATIO 5 .80	RATIO 6 1.00
HYDROGRAPH AT	000001	1.61	1	2692.	4710.	6729.	8748.	10766.	13458.
	(	4.17)	(	76.22)(	133.38)(	190.54)(	247.70)(	304.87)(	381.08)(
ROUTED TO	000002	1.61	1	849.	1665.	2630.	4376.	7118.	10661.
	(	4.17)	(	24.03)(	47.16)(	74.47)(	123.92)(	201.55)(	301.88)(

PLATE D-16

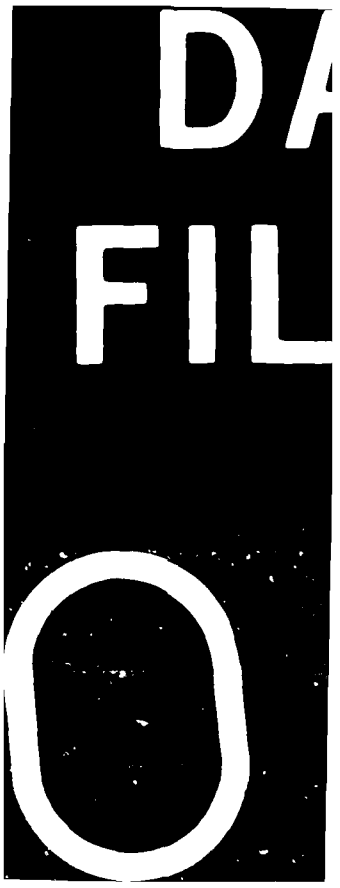
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	786.00	786.00	792.50
STORAGE	1340.	1340.	1968.
OUTFLOW	0.	0.	2850.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	789.55	0.00	1633.	849.	0.00	16.83	0.00
.35	791.05	0.00	1794.	1665.	0.00	16.67	0.00
.50	792.26	0.00	1938.	2630.	0.00	16.58	0.00
.65	793.24	.74	2056.	4376.	1.83	16.42	0.00
.80	793.84	1.34	2126.	7118.	2.58	16.25	0.00
1.00	794.39	1.89	2193.	10661.	3.08	16.17	0.00

PLATE D-17


DA
FIL